

CHAPTER TWO

THE IMPACT OF CLIMATE CHANGE ON FOOD SECURITY

María del Mar Hidalgo García

ABSTRACT

Climate change affects directly and indirectly in many aspects of food security. Agricultural production systems and livestock should undergo a transformation, mainly in developing countries, to adapt to climate change, contribute to mitigation without compromising food security and nutritional status of their populations and achieve the sustainable development of farming.

For carrying out this transformation, funding is needed. The current one is insufficient. Apart from the contribution obtained by development aid programs, agricultural systems should be considered in the allocation of funds for the fight against climate change.

Key Words:

Climate change, food security, mitigation, adaptation.

VISIT...

LANZAROTE
Caliente.COM

■ INTRODUCTION

We are beginning to experience the consequences of the gradual warming of the planet, and this will intensify over the coming decades. The momentum behind climate change is unstoppable, even if greenhouse gasses are reduced substantially.

A 2007 IPCC report concluded that the temperature increase must not exceed 2°C globally since any larger increase would have catastrophic consequences for developing countries, where droughts, increased bad weather, rising sea levels and warming of the oceans could put millions of people at risk of food insecurity.

Climate change directly and indirectly impacts many aspects of food security, particularly in the agricultural and livestock sectors. Agriculture is the main source of income and employment for 70% of the world's poor in rural areas. However, the livestock sector also makes a significant contribution to climate change, accounting for 18% of greenhouse gasses, whilst also being a prime cause of soil and water pollution⁽¹⁾.

Agricultural and livestock production systems, particularly in developing countries, must be transformed to meet these requirements, otherwise there will be serious consequences for their people and development. The challenge at present is to undertake the reforms needed to adapt to climate change, whilst offsetting its effects and maintaining food and nutritional security and sustainable farming.

The fourth IPCC report found that one of the most serious consequences of climate change will be an increase in the number of people suffering from malnutrition, mainly due to adverse effects on global farming production, as millions of people depend on subsistence farming. Indeed, weather conditions have always been a challenge for farmers.

Agriculture is therefore the sector most vulnerable to climate change, directly impacting the economic activity of countries and increasing the risk of hunger and malnutrition. This leads to a vicious cycle, as the poorest suffer the worst consequences of the adverse weather caused by climate change, whilst having the least capacity to deal with them, due to poor nutrition, the number of people affected, drinking water shortages and poor sanitation; this in turn leads to the rapid spread of infectious diseases and failings in social protection systems.

⁽¹⁾ <http://datos.bancomundial.org/tema/agricultura-y-desarrollo-rural>. As of 25 February 2012.

However, agricultural development is also the most effective tool against hunger and poverty, as it is two to four times more effective than other sectors at increasing the income of the poorest⁽²⁾.

There is an urgent need to identify the direct impact that climate change will have on agricultural production in different regions, and to establish the reciprocal relationship through which agricultural activity contributes to increasing greenhouse gas emissions, as this will impact significantly on the design and funding of policies to combat climate change. This is the only way in which measures can be implemented to make agricultural systems more *resilient* to the climate, and to achieve efficient resource usage that does not undermine future food security.

Climate change has very specific local effects. Even so, regional impacts are expected to be most severe in developing areas⁽³⁾. For example, the productivity of rain-fed agriculture is expected to fall by up to 50% in some countries, potentially undermining their food security. The area of arid and semi-arid land is also expected to increase by between 5% and 8% by 2080.

The outlook in Asia is equally discouraging. Fresh water levels are expected to fall in major river basins, and we can also expect higher sea levels and increased flooding in river deltas.

■ DIRECT IMPACTS OF CLIMATE CHANGE ON AGRICULTURE AND LIVESTOCK ACTIVITIES

■ The Effect of Higher Temperatures

Agriculture is perhaps the most sensitive of all food security activities to climate changes.

Agricultural and livestock farming has adapted to the local climate throughout the world. This has influenced what is grown and how, the type of rural buildings and the lifestyles of farming communities. This is the result of experience, the way that people have adapted to their environment and the passing of agricultural knowledge from generation to generation.

Scientific studies have found that increasing temperatures will, obviously, have different effects on farming in different parts of the world. Productivity may increase in medium and high latitudes due to longer growing seasons.

⁽²⁾ Ibid.

⁽³⁾ http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_sp.pdf.

In Europe, crops traditional to the south, such as maize, sunflower and soy, could flourish at higher latitudes, leading to harvests increasing by around 30% by 2050, depending on the crop⁽⁴⁾. A 2°C temperature increase in medium latitudes could result in a 10% increase in wheat production, but would result in a corresponding loss in lower latitudes⁽⁵⁾.

However, in semi-arid and tropical regions, where farming conditions are extreme, a temperature increase could result in reduced harvests, increasing the stress of high temperatures, with increased water loss through evaporation, further increasing water stress for plants. Soil fertility could also be affected by increased air temperatures.

Furthermore, losses from evaporation and longer growing seasons could result in increased water demand in the Middle East, North Africa and South-East Asia⁽⁶⁾.

■ Changes in Rainfall Patterns

Water is essential for plant life. Any change to rainfall patterns would impact directly on agriculture, 80% of which is dependent on rainwater⁽⁷⁾.

It is very difficult to predict the effects of global warming on rainfall in a particular region as a result of the changes this will cause to atmospheric circulation patterns. Nevertheless, most of the forecasts produced conclude that there will be an increase in rainfall at high latitudes in winter, with lower rainfall in tropical and subtropical regions.

In certain places, such as India, it is more useful to establish the seasonal changes that might occur, rather than talking about annual precipitation. In this region, there is expected to be lower rainfall in the dry season, with higher rainfall throughout the rest of the year, including the monsoon season⁽⁸⁾.

It has been estimated that rainfall shortages in certain African countries dependent on cultivation of non-irrigated and semi-humid crops could reduce production by 50% by 2020⁽⁹⁾. This would expose 70% of the population dependent on such crops on the continent to serious food insecurity.

⁽⁴⁾ Olesen, J.E et. al. «Uncertainties in projected impacts of climate change on European agricultural and terrestrial ecosystems based on scenarios from regional climate models.» *Clim. Change* 81, 123-143 (2007).

⁽⁵⁾ Jemma Gornall et al. Implications of climate Change for agricultural productivity in the early twenty-first century. *Phil. Trans. R. Soc.* 365, 2973-2989. 2010.

⁽⁶⁾ Ibid.

⁽⁷⁾ Ibid.

⁽⁸⁾ Christensen, J.H et al. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

⁽⁹⁾ Altieri M.A. and Nicholls C. «Cambio climático y agricultura campesina: impactos y respuestas adaptativas». University of California, Berkeley, USA.

Maize would be one of the crops most affected by increased temperatures and changing rainfall. Some studies have found that output might decrease by 10% by 2055, mainly in Africa and Latin America, affecting over 170 million small-scale farmers in those regions⁽¹⁰⁾.

■ Extreme Weather

Meteorological records shows that heat waves have been more frequent since the end of the last century, and this trend is expected to continue over coming decades⁽¹¹⁾. Together with lack of rainfall, this directly impacts the performance of some crops. The adaptation of crops to these occasional temperature increases varies depending on the geographic region. The impact in more temperate zones will be lower than in hotter zones, where agriculture is already at the limit of its ability to adapt, and where it might be faced by conditions that have never been experienced before⁽¹²⁾.

If there is a heat wave during a key period in the plant's development, such as when it is flowering, this could have a serious impact on the harvest.

■ Drought

Drought is a regional phenomenon, with different characteristics depending on the climatic region, frequency and duration. Although there is no general description of what constitutes a drought, they are a natural catastrophe that affects a large part of the population, with high economic, social and environmental costs⁽¹³⁾.

Lack of rainfall causes water stress in plants and, as with heat waves, the areas most affected will be those already suffering extreme water shortages.

Dryness of the soil stops root growth and decomposition of organic material, further decreasing soil fertility. However, droughts have further effects, as they increase soil erosion due to reduced plant cover; this is of particular concern on mountainsides.

One of the results of climate change will be an increase in the severity of droughts, both in terms of their frequency and duration, such as that affecting the Horn of Africa in late-2011, with famine affecting 13 million people⁽¹⁴⁾.

⁽¹⁰⁾ Jones, P. G. and Thornton P.K. «The potential impacts of climate change on maize production in Africa and Latin America in 2055». *Global Environmental Change* 13:51-59.

⁽¹¹⁾ According to a scientific study published in *Nature* magazine (issue 432), heat waves in Europe will increase by 50%.

⁽¹²⁾ For example, peanuts can grow in semi-arid regions at temperatures of up to 40°C. However, a slight increase of just 2°C, even if only for a short time, reduces the crop.

⁽¹³⁾ Drought monitoring and early warning: concepts, progress and future challenges. WMO, 2006.

⁽¹⁴⁾ Message from Ban Ki-Moon, 16 October 2011.

Forecasts suggest that by 2050, the proportion of the earth subject to constant drought will increase from 2% to 10%, with the area suffering from extreme droughts increasing from 1% to 30% by the end of the 21st century⁽¹⁵⁾.

■ **Torrential Rain, Flooding and Tropical Storms**

Experts believe that there will be an increase in the amount of water falling as torrential rain over coming years. Excess water can damage crops, ruining harvests. And flooding can devastate large expanses of cultivated land.

Tropical cyclones may become more intense over the coming decades, with stronger winds and higher rainfall⁽¹⁶⁾. However, there is no expert consensus on whether they will become more frequent.

Tropical cyclones usually occur in summer or the early autumn: from May to November in the northern hemisphere and from November to April in the southern hemisphere. These cyclones can have serious social and economic impact, particularly in developing areas. This is critical in the Indian Ocean region, where the majority of the population lives in river deltas, for example in Myanmar, Bangladesh and India. Increasing populations in these areas make them extremely vulnerable to the risk of flooding, which will be aggravated by the loss of harvests.

However, inland regions may benefit from these weather systems as they decay to heavy rain. This happened for example with cyclone Eline which devastated agriculture in Madagascar in 2000, but whose subsequent rains helped to offset drought in the south of Africa.

■ **INDIRECT IMPACT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION AND LIVESTOCK**

■ **Increased Infestations and Diseases**

Higher temperatures resulting from climate change may spread insects and pathogens to a wider range of latitudes. It is very difficult to forecast the effect of this on future agriculture, as this depends not just on the presence of the pathogen, but also on the condition of the crops; these two factors cannot be considered separately as they influence one other.

Climate change may cause -and is in fact already causing- changes to the geographic distribution of diseases, changing the dispersion of bacteria and

⁽¹⁵⁾ Report: «Migration and Climate Change». IOM Research Migration Series n° 31, 2008.

⁽¹⁶⁾ Fourth IPCC report. 2007.

fungi as wind patterns change, leading to the appearance of emerging and re-emerging illnesses, and an increase in the severity of pathogens⁽¹⁷⁾.

■ Water Supply

Irrigated crops account for 20% of cultivated land globally, but for 40% of the food produced⁽¹⁸⁾. In these cases, the water used is drawn from rivers; as a result availability depends on weather in remote areas. One example of this is agriculture along the length of the Nile, which depends on rainfall in its highest stretch in Ethiopia.

In other regions, river flows depend on ice melting. In medium and high latitudes, mild winters result in lower precipitation in the form of snow, resulting in reduced water flow in spring. Almost a sixth of the world's population lives around the Ganges and Indus river basins, using their waters for domestic and agricultural purposes. Both rivers depend on melting of glaciers in the mountains, and this in turn is being influenced by global warming. This phenomenon may result in seasonal flows in both rivers, decreasing in the dry season and increasing in the rainy season with greater risks of flooding. Combined with increasing populations in the area, this could result in water shortages in future.

In other situations, water shortages are not due to low rainfall, but to surface run off, evaporation and deep percolation⁽¹⁹⁾.

■ Rising Sea Levels

Rising sea levels are an inevitable consequence of climate change. There are two main reasons for this increase: thermal expansion of the oceans and an increase in the mass of water due to ice melting from warming. Although these effects should be taken into account at present, they are not expected to occur in the short term, given the rate of ice melting in the major ice shelves at present. The fourth IPCC report estimates that sea levels could rise by between 0.1 m and 0.5 m.

The most vulnerable regions to such changes are those in river deltas and island states in South-East Asia, which could suffer flooding of crops and salination of underground water sources.

⁽¹⁷⁾ Rosenzweig, C. and D. Hillel. «Climate change and the global harvest: potential impacts of the greenhouse effect on agriculture. Oxford University Press, New York.

⁽¹⁸⁾ Döll, P and Siebert, S. Global modeling of irrigation water requirements. *Water Resour. Res.* 38.

⁽¹⁹⁾ Altieri, M and Nicholls, C. «Cambio climático y agricultura campesina: impactos y respuestas adaptativas». University of California, Berkeley, USA.

■ Mass Migrations

Environmental degradation is one of the main causes of mass migrations at present, both intra and inter-state. This is increasing with climate change and has even led to coining of terms such as «environmental migrations» or «environmental refugees», and even original coinings such as «climigration»⁽²⁰⁾. This is a complex relationship and very hard to predict, in which migrations can be considered either a consequence of the ineffectiveness of policies to cope with climate change in the source countries, or as a means of adapting to climate change.

The most critical areas, and those requiring the greatest attention, are small island states, the Sahara, semi-arid areas in southern Africa, Latin America and the Caribbean and central and southern Asia.

The IPCC has estimated that by 2050 around 150 million people will have been forced to migrate from their homes as a result of the effects of climate change. Most of these will be in developing countries, and this mass migration may result in tension and conflict in the areas they move to⁽²¹⁾, whether in refugee camps or in urban areas. In refugee camps, mass concentrations often lead to extreme conditions, such as malnutrition, poor hygiene, disease and pollution. With migrations to urban areas, refugees often settle on the periphery, usually in areas lacking basic social services. This leads to heightened social inequalities, resulting in increased criminality and class conflict.

■ The Effects of Changes in Atmospheric Composition

A higher concentration of CO₂ in the atmosphere may have a direct effect on physical processes in plants, such as photosynthesis and transpiration. In general, studies show that increased CO₂ in the atmosphere increases photosynthesis by between 10% and 50%; this is beneficial⁽²²⁾. However, comparing the overall effect of CO₂ on fertility with the results of climate change, the experts consider that the former is much more critical for determining whether harvests increase or decrease. If CO₂ fertilisation remains high, climate change will benefit agriculture in Europe and the USA. However, in Africa and India, despite the increased fertilisation levels resulting from higher CO₂, climate change will result in harvests falling by 5% by 2050⁽²³⁾.

However, ozone hampers photosynthesis and accelerates leaf ageing, impacting on harvests. These effects are particularly visible in agricultural products, reducing their market value.

⁽²⁰⁾ <http://www.guardian.co.uk/global/2009/apr/17/alaska-migration-climate-change>.

⁽²¹⁾ Reuveny, R. «Climate change induced migration and violent conflict». *Political Geography*. 2007. Vol. 26, Issue 6. 656-673.

⁽²²⁾ Jemma Gornall et al. 2010 op.cit.

⁽²³⁾ Ibid.

■ ADAPTATION OF AGRICULTURAL SYSTEMS TO CLIMATE CHANGE

The fourth IPCC report states that the maximum increase in global temperatures must be limited to 2°C. This means that greenhouse gas emissions will have to be reduced. The temporary extension of the Kyoto Protocol until the end of 2013 and the commitment to establishing a new protocol in 2015 have set the pace of international progress towards a global agreement to reduce greenhouse gas emissions, contributing to offsetting the effects of climate change.

Meanwhile, many farmers are starting to feel the effects of climate change and the poorest countries are seeing their subsistence threatened.

Climate change is unstoppable, but the sooner this is accepted the sooner appropriate measures can be taken to adapt and to counter its negative effects and boost its positive effects, which we must also seek to do. Adapting is as, or almost as, important as offsetting these effects. Therefore, adapting farming to this new scenario must be a priority. Those who can adapt best and most quickly will be the most sustainable and the most competitive.

The IPCC defined adaptation in 2001 as «adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation».

Unlike mitigation, adaptation cannot be considered from a global perspective. Every region has its own peculiarities, with the adaptation measures required varying from place to place.

The challenge of adapting is much more difficult for developing countries because, in addition to being more exposed to the effects of climate change and being more vulnerable, they have weaker institutions and limited access to technology and markets⁽²⁴⁾.

The Cancun Adaptation Framework⁽²⁵⁾ establishes an inter-country adaptation framework for sharing information and capabilities, guaranteeing financial flows to more vulnerable countries, which are often those that contribute least to climate change.

According to the IPCC definition «the extent to which systems are susceptible to climate change is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the

⁽²⁴⁾ Mitigation of climate change and adaptation of agriculture, forestry and fishing.

⁽²⁵⁾ In the United Nations Framework Convention on Climate Change. Decision 1/CP.16.

system to changes in climate». Adaptation capacity relates to the capacity to take on climate change to moderate its potential impact, benefit from new opportunities and handle its consequences

The experts argue that the farming sector should focus on the following areas:

- a Analysis of «hot spots».*
- b Improvement and integration of weather forecasting systems.*
- c Early warning systems for serious weather conditions.*
- d Appropriate handling of risks resulting from natural disasters and the preparation of contingency and social aid plans.*
- e Rural investment: harvest insurance, incentives and the adoption of best farming and land use practices.*
- f Improvement of water storage and conservation systems.*
- g Water reuse.*
- h Desalination.*
- i Increased efficiency of water use and irrigation.*
- j Changes to planting cycles for different crops.*
- k Improvements to land management to avoid soil erosion.*
- l Implementation of disease monitoring systems to warn of possible outbreaks.*

■ Climate Change Adaptation Policies in the Agricultural Sector

71

Measures to ensure food security in the face of climate change must aim to achieve sustainable and robust agricultural development, taking into consideration the needs of the most vulnerable, such as women and children, whilst improving nutritional quality, as appropriate nutrition helps make the population more resistant to the consequences of climate change, such as disease outbreaks and poor hygiene.

Nutrition must not only be taken into account in agricultural production (where paradoxically, increased crop production does not always lead to better nutrition for the population), but also food storage and processing so as to avoid loss of nutrients⁽²⁶⁾.

As previously stated, the adaptation has to be very local and focused on the characteristics of the population and the geographic area, no matter how small. The main starting point is that there is no single solution, and neither technological development nor increased production will necessarily lead to increased food security in the face of climate change.

⁽²⁶⁾ Report «Climate change and nutrition security» by the SCN for the 16th Convention of Parties in Cancun, 2010.

Adaptation policies must consider technological progress, but must also pay attention to the traditional agricultural practices of small farmers and indigenous communities.

■ The Role of Traditional Agriculture

Traditional farmers have demonstrated sufficient capacity to adapt to extreme conditions by applying adaptation over many centuries, based on in-depth knowledge of local conditions and crop diversity⁽²⁷⁾. The practices used in this type of agriculture include polycultivation, exploitation of local genetic diversity (as local genetic variations offer the greatest resistance to extreme weather conditions), collection of wild plants and agroforestry.

■ Climate-Smart Agriculture

Investment in the agricultural sector must aim to contribute to food security, considering sustainable development, adaptation to climate change and its contribution to mitigation. These factors are included in what the FAO has called «Climate-smart agriculture».

The FAO defines this as being agriculture that sustainably increases productivity and resilience (adaptation) and productivity of agricultural production systems, whilst also reducing and removing emissions⁽²⁸⁾.

The smart-agriculture concept includes aspects related to improving production systems, policy coordination locally, nationally and internationally and finance for the transformation needed by agriculture.

• *Improvements in Production Systems*

The FAO has set out the key factors required for sustainable agricultural production. These include:

- Appropriate soil and nutrient management, based on practices that reduce needs for synthetic fertilisers.
- Improvements to the management of ecosystems and agricultural biodiversity.
- Use of genetic resources, both through preservation of natural genetic resources and the generation of new varieties that are more resistant to adverse climate conditions, pests and diseases, and adapting production cycles.
- Improved post-harvest preservation, both in storage and distribution.
- Implementation of agricultural conservation⁽²⁹⁾.

⁽²⁷⁾ Altieri. M. A and Nicholls C. Opus cit.

⁽²⁸⁾ Climate-smart agriculture. Policies, practices and financing for food security, adaptation and mitigation. FAO. 2010.

⁽²⁹⁾ According to the FAO, conservation agriculture helps with adaptation to climate change, reducing crop vulnerability. This consists of agricultural practices such as:

1. Minimum mechanical disturbance of the soil.

- Agroforestry⁽³⁰⁾.
- Developing urban and peripheral agriculture.
- *Local, National and International Policy Coordination*

The FAO has highlighted the need to establish consistency amongst policies to fight climate change and for agricultural development and food security. This requires:

- Fostering institutional and political support to channel investment, social security networks and access to insurance and land.
- Spreading information amongst agricultural communities on sustainable agricultural practices, together with information from early-warning systems for bad weather.
- *The Need for Finance*

the concept of «climate-smart agriculture» recognises that finance, investment and political commitment is needed to implement the changes to agriculture needed to adapt to climate change and ensure food security. This very necessary transformation of the agricultural sector also includes its capacity to make a significant contribution to mitigation.

There is a wide gap between the cost of adapting agricultural systems to climate change and the finance provided, mainly from development funds. Action is required to ensure that financing mechanisms and public and private funds for combating climate change consider the agricultural sector and food security.

■ THE ROLE OF THE AGRICULTURAL SECTOR IN MITIGATION

■ The Contribution of the Food Supply Chain to Climate Change

- *Greenhouse Gas Emissions*

Agricultural activity directly contributes 12% of greenhouse gas emissions⁽³¹⁾, mainly nitrous oxide⁽³²⁾. Agriculture also contributes a further 12% from changes in land use. We also need to include the contribution of the industrial sector directly related to agriculture (pesticides, fertilisers and

2. Conservation of an organic covering to cover and feed the soil.

3. Crop rotation, sequencing and association.

⁽³⁰⁾ Agroforestry consists of protecting crops by planting trees to provide appropriate cover to maintain soil humidity and to reduce temperatures, wind impact and direct sunlight.

⁽³¹⁾ Figures provided in the conference by Jean Francois Soussana, member of the FAO's experts group on «Greenhouse gas emissions in agriculture». Bilbao, 8 March 2012.

⁽³²⁾ Nitrous oxide is 296 times more harmful than CO₂.

machinery). This is of particular concern in Latin America, where agriculture generates 22.9 % of emissions, whilst deforestation and changes of land use account for 53%⁽³³⁾.

It is «very likely» that agriculture, together with the use of fossil fuels, has made the largest contribution to the increase of atmospheric CH₄ and that it is also responsible for increases in CO₂⁽³⁴⁾.

These high figures show that the agriculture sector has enormous potential to contribute to mitigating climate change, increasing carbon capture in the soil through better use of agricultural and pasture land and the recovery of degraded land.

The FAO⁽³⁵⁾ considers that the following practices could reduce greenhouse gas emissions:

- Reducing deforestation and degradation of forests.
- Fostering carbon retention.
- Improving control of forest fires.
- Stopping burning of farming waste.
- Adopting systems that do not use land clearance to reduce emissions from arable cultivation.
- More efficient energy use in agriculture and associated industries.
- More efficient management of nitrogen and manure fertilisers and cultivated land.
- More efficient irrigation of rice fields⁽³⁶⁾.

The livestock sector also makes a significant contribution to greenhouse gas emissions.

The FAO⁽³⁷⁾ forecasts that global meat production will more than double from 229 million tons in 1999/2001 to 465 million tons in 2050, and that milk production will increase from 580 to 1043 million tons in 2050.

Livestock is also one of the most damaging sectors for environmental impact, as it degrades land, drives climate change, increases air and water pollution, and reduces biodiversity. About 30% of the earth's land surface is used for livestock, the major land use on the planet. In total, 70% of agricultural land is used for livestock production.

⁽³³⁾ CAIT database, World Resources Institute, 2005. The predominant gasses are methane and nitrous oxide.

⁽³⁴⁾ http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_sp.pdf

⁽³⁵⁾ «Climate change and food security: a framework document. FAO. 2007.

⁽³⁶⁾ Wetlands, particularly rice fields, contribute significantly to methane emissions.

⁽³⁷⁾ «Livestock's long shadow». FAO 2009.

Around 20% of all pasture and grazing land in the world is totally or partially degraded as a result of livestock (over-pasturing, compacting, soil erosion, etc.). This is more serious in arid lands, where livestock is the only form of subsistence.

Livestock contributes 18% of greenhouse gas emissions. Livestock is responsible for a large share of human-induced climate change⁽³⁸⁾:

- 9% of CO₂ emissions are associated with expansion of pasture land and production of animal feed.
- 37% of methane emissions come from the enteric fermentation of ruminants. The global warming potential (GWP) of this is 23 times that of CO₂.
- 65% of nitrous oxide originates from manure, with a GWP 296 times that of CO₂.
- 64% of the ammonia that contributes to acid rain and the acidification of ecosystems.
- These levels are so high that they provide sufficient margin to offset global warming through reduced greenhouse gas emissions. The main measures suggested by experts to achieve this reduction are:
 - Increasing the productivity of livestock systems to avoid deforestation and degradation of pasture land.
 - Restoration of desert pasture land to increase carbon retention in the soil.
 - Methane and nitrous oxide emissions can be reduced by improving the nutrition of ruminants and handling of manure.
 - More effective management of livestock waste.

Another aspect to be included in the food sector's contribution to greenhouse gas emissions is that it accounts for 30% of global energy consumption and over 20% of total global greenhouse gas emissions⁽³⁹⁾.

The FAO is seeking «energy-smart food for people and the climate», this includes: access to energy for all, improved energy efficiency at all stages of the food supply chain and the replacement of fossil fuels by renewable energies in the food sector.

Measures to make energy usage in the food sector smarter include using more efficient engines, use of precision fertilisers, monitoring irrigation and selective water supply, introduction of agricultural practices without tilling and the use of agricultural varieties and animal breeds that are less dependent on consumption⁽⁴⁰⁾.

⁽³⁸⁾ Ibid

⁽³⁹⁾ According to the FAO report submitted at the World Climate Change Conference in Durban in late 2011. The food sector includes production of factors of production, production, processing, transport, marketing and consumption.

⁽⁴⁰⁾ According to the FAO report submitted at the World Climate Change Conference in Durban in late 2011.

- *Deforestation*

Although the FAO announced in late 2011 that the area of land deforested had been one third less than estimated in 1990-2005, deforestation continues to be a threat to the environment, for food security and the economic welfare of many communities. This is a rapid process that has accelerated over recent years due to the expansion of agriculture, infrastructure construction and demand for wood. The scale of global deforestation -mainly due to conversion of tropical forests into land for cultivation- was 14.5 million hectares on average between 1990 and 2005⁽⁴¹⁾.

The causes of deforestation vary in different regions. In Africa it is caused by small-scale agriculture and wood gathering. In Latin America it is caused by large-scale agriculture and extensive livestock farming. The causes in the Asia Pacific region are more varied, although agriculture plays a leading role⁽⁴²⁾. In conclusion, in two thirds of the countries where the agricultural sector has increased, this has been accompanied by a reduction in the area of forest⁽⁴³⁾.

Some governments and international organisations argue that the main cause of deforestation is subsistence rather than modern agriculture. Migratory «cut and burn» agriculture is the cause of degradation and soil erosion, in addition to loss of forest mass. The consequences of deforestation are most apparent in the Amazon region. Over the last ten years, Brazil has lost 2.6 million hectares of forest, mainly from the Amazon, whilst livestock production has increased by 9%⁽⁴⁴⁾.

Decreasing deforestation and fostering sustainable exploitation of carbon-capturing forests are two of the main approaches by international funds to the fight against climate change.

■ Mitigation Without Compromising Food Security

Agricultural activity plays two important roles in the fights against climate change: it is part of the problem, but also part of the solution. We can however go further, and state that mitigation could benefit food security⁽⁴⁵⁾.

Nevertheless, agriculture's potential contribution to mitigation should not be undervalued. A number of studies are currently underway to provide reliable tools for measuring this contribution.

⁽⁴¹⁾ According to the FAO, data obtained by satellite.

⁽⁴²⁾ FAO (2001).

⁽⁴³⁾ FAO report «State of the world's forests».

⁽⁴⁴⁾ iAmazon Alive! A decade of discoveries: 1999-2009.WWF, 2010.

⁽⁴⁵⁾ Report «Climate change and nutrition security» by the SCN for the 16th Convention of Parties in Cancun, 2010.

- *Carbon Retention in the Agricultural Sector*

Soil is the second most important reservoir of organic material. However, changes to rainfall patterns, increasing temperatures due to climate change and agricultural practices focusing on productivity have reduced the amount of organic material in the soil, resulting in its degradation.

Particular attention must be paid to increasing the volume of organic material in the soil, as retaining carbon in the soil could make a significant contribution to decreasing atmospheric CO₂ emissions. Experts estimate that land ecosystems have the capacity to absorb 13% of the CO₂ in the atmosphere⁽⁴⁶⁾.

In addition to helping to mitigate the effects of climate change, appropriate management of organic matter in the soil is also a form of adaptation to stop desertification and the negative effects of prolonged droughts, as organic material in the soil can absorb up to twenty times its own weight in water⁽⁴⁷⁾.

The FAO proposes the following ways of increasing organic matter⁽⁴⁸⁾:

- Fostering forestation and reforestation.
- Introducing agroforestry systems, combining crops, pasture land and trees sustainably.
- Recovery of pasture lands. Land in arid and tropical regions has been seriously degraded by poor use.
- In agricultural land, the solution consists of conservation agriculture; this includes leaving land fallow and covering the soil with vegetable matter, whether living plants or waste from these, and crop rotation.
- Change of use of degraded land for fuel biomass production and creation of productive forests.

- *Agriculture and Carbon Markets*

Although the agricultural and forestry sectors can make a significant contribution to decreasing the concentration of greenhouse gases in the atmosphere, they have not been taken into account in carbon credit programmes. These programmes finance greenhouse gas emission reduction and carbon capture projects. This has mainly been due to the difficulty of quantifying the volume of carbon retained in the agroforestry sector.

⁽⁴⁶⁾ Report on the «Climate change: can soil make a difference?» conference held on 12 June 2008. http://ec.europa.eu/environment/soil/pdf/report_conference_es.pdf

⁽⁴⁷⁾ This case shows how adaptation and mitigation can go hand-in-hand in the search for finance.

⁽⁴⁸⁾ Climate change and food security: a framework document. FAO.

In late 2011, the FAO⁽⁴⁹⁾ presented its «Methodology for sustainable grassland management», which is being applied in China's Qinghai province⁽⁵⁰⁾. This methodology enables us to estimate the reduction of greenhouse gas emissions and the increase in carbon capture in the soil resulting from sustainable grassland management⁽⁵¹⁾. As a result, farmers in the area can sell carbon credits in markets that trade emission rights as a financing method to continue with their activities, whilst mitigating climate change. This is a pilot study, but it is opening the door by considering the significant role that could be played by the agricultural sector in mitigating climate change.

The methodology has been presented to the VCS (Verified Carbon Standard)⁽⁵²⁾ for approval.

- *The rise of biofuels*

The obligation to reduce the use of fossil fuels is encouraging the use of other energy sources, including biofuels. However, the purchase of extensive areas of land in developing countries to grow such crops conflicts with the fight against hunger and the need to ensure food security for the poorest communities.

■ FINANCING SUSTAINABLE AGRICULTURE

Finance is needed to adapt the agricultural sector in developing countries. However, very little work has been done to estimate how much is needed. The World Bank has produced an approximate estimate that the «investment required could be between 75 and 100 billion dollars per year in developing countries»⁽⁵³⁾. The World Bank increased its commitment to 9 billion at the end of 2012⁽⁵⁴⁾. However, there is obviously still a significant gap⁽⁵⁵⁾.

⁽⁴⁹⁾ The methodology was developed in collaboration with the Academy of Agricultural Sciences, the Chinese Academy of Sciences and the World Agroforestry Centre (ICRAF, for its French acronym).

⁽⁵⁰⁾ The methodology is based on the «Three Rivers Grassland Carbon Sequestration Project». This consists of improving the management of grasslands through practices such as rotation of grazing animals in summer and winter, limiting the time and number of animals in degraded grasslands, and restoration of degraded land through planting of perennial grasslands for long-term usage.

⁽⁵¹⁾ «Sustainable grassland Management Practices (SGM)».

⁽⁵²⁾ *Verified Carbon Standard (VSC)* is a not-for-profit body that certifies greenhouse gas emission reduction programmes worldwide so that they can issue carbon credits for trading in emissions markets.

⁽⁵³⁾ World development report. 2010. World Bank.

⁽⁵⁴⁾ <http://www.bancomundial.org/es/news/2012/07/30/food-price-volatility-growing-concern-world-bank-stands-ready-respond>

⁽⁵⁵⁾ The FAO's «Climate-smart agriculture» report is very clear on this, stating: that «available financing, current and projected, are substantially insufficient to meet climate change and food security challenges faced by the agriculture sector».

Mitigation strategies in the agricultural sector can also contribute to the development of sustainable practices that ensure adaptation to climate change, helping to achieve food security and sustainable development in developing countries. However, this synergy has not been recognised sufficiently. Food security must also have a place on the climate change agenda, as has often been proposed by a number of international institutions, including the FAO.

Despite the objective of the United Nations Framework Convention on Climate Change (UNFCCC) being to stabilise greenhouse gas emissions *to enable ecosystems to adapt naturally to climate change, ensure that food production is not threatened and to permit sustainable economic growth*, agriculture⁽⁵⁶⁾ and food security have never played a major part in international negotiations on climate change.

However, agriculture should play a greater role. The Convention states that the Party States should cooperate in this sector to establish adaptation and mitigation measures⁽⁵⁷⁾.

At the most recent Conference of Parties, held in Durban, there was a glimpse of a possibility that this situation might change and agricultural activity might have access to funds for fighting climate change. In order to intensify cooperation in certain sectors in relation to mitigation, the Conference agreed that its Subsidiary Body for Scientific and Technological Advice should examine issues related to agriculture so as to share opinions and for the Conference of Parties to make a decision in this regard at its 18th session⁽⁵⁸⁾.

Quantifying agriculture's contribution to climate change is a first step to accessing funds for adaptation and mitigation. The recently launched Green Fund for the climate may be a source of finance for the fight against climate change in developing countries⁽⁵⁹⁾ in order to foster sustainable agriculture.

⁽⁵⁶⁾ With the exception of agreements on deforestation, land use and changes of land use.

⁽⁵⁷⁾ Article 5 c) and e).

⁽⁵⁸⁾ <http://unfccc.int/resource/docs/2011/cop17/spa/09a01s.pdf>

⁽⁵⁹⁾ According to the FCCC/CP/2011/9/Add.1a report *«The Fund will contribute to the achievement of the ultimate objective of the United Nations Framework Convention on Climate Change. In the context of sustainable development, the Fund will promote the paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate change.... The Fund will strive to maximize the impact of its funding for adaptation and mitigation, and seek a balance between the two, while promoting environmental, social, economic and development co-benefits and taking a gender-sensitive approach».*

■ CONCLUSIONS

feeding a population of 9 billion people by 2050 without increasing greenhouse gas emissions is one of the world's great challenges.

Climate change has, and will increasingly have in the near future, direct and indirect effects on food security in developing countries; and such countries are the most vulnerable to its consequences. This creates a vicious circle, as a malnourished population is less resistant to the effects of climate change, such as the spread of diseases.

To achieve food security at a time of climate change, the agricultural sector in developing countries needs to undergo a profound transformation. This process must consider the synergy between adaptation capacity and the mitigation opportunities offered by sustainable agriculture or «*climate-smart agriculture*», which take into account traditional practices, biodiversity and the fundamental role of rural women in developing countries.

This transformation of agricultural systems requires finance. This is not currently sufficient and there is a clear «financing gap». Apart from funds from development aid programmes, agriculture must also have access to funds for fighting climate change. However, the main problem is that there are no mechanisms to quantify the contribution of the agricultural sector as, to date, agriculture has not played a major part in international negotiations on the reduction of greenhouse gas emissions. This may change. One of the decisions at the Durban Conference was that the Subsidiary Body for Scientific and Technological Advice should examine issues related to agriculture.

Nevertheless, if such a contribution is established, both mitigation and adaptation strategies in developing countries must consider food security to avoid developing countries being monopolised by large areas taken over for biofuels or monocultivation as the agricultural sector enters carbon markets. Mitigation must not compromise food security.